SPECIFICATION

1. Title of the invention

MICROWAVE-HEATING AND PULVERIZING DEVICE

2. Scope of claims for patent

1. A microwave-heating and pulverizing device comprising:

an oven to which microwave is supplied;

a cylindrical container which is made of a microwave transmissive material and rotatably supported in the oven;

a rotary drive mechanism configured to rotatably drive the cylindrical container; and

numerous heating bodies functioning also as pulverizing media, which are made of a microwave absorbent material and contained in the cylindrical container,

wherein an inner space of the cylindrical container and an inner space of the oven are completely separated, and

on one side of the cylindrical container, a supply part for introducing a substance to be processed is provided, while on the other side of the cylindrical container, a discharge part for discharging a powder product is provided.

3. Detailed description of the invention

[Application field in industry]

The present invention relates to a device including a cylindrical container made of a microwave transmissive material which contains numerous heating bodies made of a microwave absorbent material, the device being capable of microwave-heating and pulverizing a substance to be processed while rotating the cylindrical container.

Specifically, the present invention relates to a device that performs processes, such as denitration, roasting, reduction and pulverization, on a plutonium nitrate or uranyl nitrate solution or a mixture thereof recovered at a device reprocessing plant, to thereby convert the solution into oxide powder having a uniform particle size and constant physical properties.

[Background art]

There has been known a method in which a nuclear fuel material, such as plutonium nitrate or uranyl nitrate solution or a mixture thereof, is concentrated and dried using microwave heating and then subjected to denitration decomposition, to thereby convert directly into an oxide. For such a conventional technique, there can be mentioned a batch method using a single stainless steel plate, a semi-batch method using a several stainless steel

plates, and a stainless steel screw feeder method.

When an object with protrusions is placed in a microwave oven, electrical discharge by microwave occurs and thus a thermometer, such as thermocouple, cannot be inserted into an object. Accordingly, temperature has been remotely measured using an infrared thermometer, and heating is controlled based thereon.

Such a direct denitration method using microwave heating has advantages that steps and operations are simple, and the obtained powder exhibits extremely excellent degree of sintering.

[Problem to be solved by the invention]

Microwave is reflected on a metal surface, and thus the efficiency of microwave absorption decreases in the vicinity of the metal surface. Therefore, the prior art using a plate or screw feeder made of stainless steel has disadvantage that the heating efficiency by microwave is poor.

In order to remotely measure a temperature using the infrared thermometer, it is required to observe well a surface of the substance to be processed. However the prior art device has disadvantages that the oven is filled with gas, dust and the like generated from the substance, which cover a surface of the substance, and as a result, the heating temperature is not clearly obtained, and the physical properties of the powder product becomes nonconstant.

Furthermore, when the stainless steal plate is used, a product obtained by direct denitration has a massive form, and thus it should be pulverized thereafter.

The object of the present invention is to provide a heating and pulverizing device in which: heating efficiency by microwave is high; powder having a uniform particle size can be obtained due to a pulverizing function; and a precise temperature can be measured to thereby appropriately control the heating, and thus to make physical properties of the powder constant.

[Means to solve the problem]

The present invention which can attain the above-described object is a microwave-heating and pulverizing device including: an oven to which microwave is supplied; a cylindrical container which is made of a microwave transmissive material and rotatably supported in the oven; a rotary drive mechanism configured to rotatably drive the cylindrical container; and numerous heating bodies functioning also as pulverizing media, which are made of a microwave absorbent material and contained in the cylindrical container. In the cylindrical container, an inner space of the cylindrical container and an inner space of

the oven are completely separated, and on one side of the cylindrical container, a supply part for introducing a substance to be processed is provided, while on the other side of the cylindrical container, a discharge part for discharging a powder product is provided.

When a reaction, such as denitration, roasting and reduction, is performed using microwave heating, a corresponding requisite gas is introduced from the gas supply system to the cylindrical container.

[Action]

The microwave supplied to the oven transmits through the cylindrical container and is directly irradiated on the substance to be processed, to thereby heat the substance. In addition, the heating bodies in the cylindrical container absorb the microwave to generate heat, and thus the substance is also heated indirectly. When the substance to be processed is in a form of liquid, it undergoes evaporation to dryness, and a reaction, such as denitration, roasting, reduction and the like, is performed depending on a type of the introduced gas. In this situation, the cylindrical container is rotated by the rotary drive mechanism, and the heating bodies contained in the cylindrical container make movement to collide with each other or with the container wall, which pulverizes the substance to be processed. When the reaction advances, powder body as a result of pulverization is discharged from the discharge part.

Since the inner space of the cylindrical container and the inner space of the oven are completely separated, gas, dust or the like generated during heating does not intrude into the oven, and the temperature of the substance to be processed can be precisely measured using an infrared thermometer or the like attached to the oven. Based on the measured temperature information, the microwave heating is controlled.

The thus obtained powder product has not only a uniform particle size due to pulverization, and also constant physical properties due to a precise heating control.

[Examples]

Fig. 1 is an explanatory diagram showing one embodiment of a microwave-heating and pulverizing device according to the present invention. The device includes an oven 10, a cylindrical container 12 rotatably supported in the oven 10, a rotary drive mechanism 14 for rotating the cylindrical container 12, and numerous heating bodies 16 contained in the cylindrical container 12.

In an upper portion of the oven 10, a waveguide attaching port 18 and a thermometer

attaching port 20 are formed. To the waveguide attaching port 18 is connected a waveguide from a microwave power unit (all not shown), and to the thermometer attaching port 20 is attached an infrared thermometer 22.

The cylindrical container 12 is made of a microwave transmissive material, such as silicon nitride and glass, and the oven 10 has a sealed structure in which an inner space of the cylindrical container 12 and an inner space of the oven 10 are completely separated. To one end portion of the cylindrical container 12 (in this Example, right side in the drawing), a supply line 24 for introducing a substance to be processed is connected, together with a gas supply system 26 for supplying a predetermined gas. On the other end (left side in the drawing) of the cylindrical container 12 outside the oven, a discharge part 28 having a container structure is provided, where numerous pores 30 are formed in a periphery of the cylindrical container 12, so as to discharge gas and powder body from inside. On an upper portion of the discharge part 28, an exhaust port 32 is provided, while on a lower portion, a product discharge port 34 is provided.

The rotary drive mechanism 14 is provided on an end (left side in the drawing) of the cylindrical container 12, and is configured to unidirectionally rotate the cylindrical container 12 in a direction of an arrow.

The numerous ball-shaped heating bodies 16 contained in the cylindrical container 12 are made of a microwave absorbent material, such as silicon carbide, and also function as media for pulverizing a substance 36 introduced therein, by movement accompanying rotation of the cylindrical container 12.

The device performs in the following manner. The substance to be processed is supplied from the supply line 24 to the cylindrical container 12. To the oven 10 is supplied microwave from the microwave power unit. The microwave transmits through the cylindrical container 12 and directly heat the substance 36 contained therein, while the heating bodies 16 absorb the microwave to generate heat, which further heats the substance 36. In addition, due to the rotation of the cylindrical container 12, the ball-shaped heating bodies 16 also functioning as pulverizing media make movement, by which the substance 36 is stirred, mixed and pulverized.

In these heating and pulverizing steps, the gas supply system 26 supplies gases each required for the corresponding reaction of denitration, roasting, reduction or the like, with which the reactions proceed. The substance 36 to be processed that had experienced such a

process advances in the cylindrical container 12 to the left in the drawing and reaches the discharge part 28, where a powder product 38 and the heating body 16 are separated by the pores 30 formed in the wall of the cylindrical container 12. The powder product 38 falls and is discharged from the product discharge port 34, while the heating bodies 16 remain in the cylindrical container 12. The gas, dust or the like generated during microwave heating passes through the pores 30 and is discharged from the exhaust port 32, which are then processed in a solid-gas separator - offgas processing system.

One preferred embodiment of the present invention has been described. However, the present invention is not limited to the above-described configurations. For example, the heating body is not limited to be ball-shaped but may be rod-shaped, and when heating and pulverization are simply performed without any special reaction, the gas supply system can be omitted.

[Effect of the invention]

As described above, in the present invention, the substance to be processed is put in the cylindrical container made of a transmissive material, directly heated by microwave irradiation, and indirectly heated by the heating bodies made of a microwave absorbent material contained in the cylindrical container. Therefore, microwave irradiation efficiency and heating efficiency are improved, as compared with the conventional device using metals.

Since the inner space of the cylindrical container and the inner space of the oven are completely separated, gas, dust or the like generated during the heating step does not spread in the oven, and the temperature of the substance can be precisely measured using the infrared thermometer. This enables an appropriate automatic temperature control and physical properties of the powder product become constant.

Since the numerous heating bodies contained in the cylindrical container also function as pulverizing media, the substance to be processed can be pulverized during the heating step, to thereby obtain powder having a uniform particle size.

Furthermore in the present invention, even though the substance to be processed is in a form of a solution, the substance can be consistently and sequentially processed to the powder form.

4. Brief description of the drawings

Fig. 1 is an explanatory diagram showing an embodiment of a microwave-heating and pulverizing device according to the present invention.

10 ... oven

12 ... cylindrical container

14 ... rotary drive mechanism

16 ... heating body

18 ... waveguide attaching port

22 ... infrared thermometer

24 ... supply line for introducing substance to be processed

28 ... discharge part

36 ... substance to be processed

Fig. 1